REMARKS

ON THE

MECHANICAL STRUCTURE

OF

COTTON FIBRE.

BY

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OF BOLTON.

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REMARKS ON THE MECHANICAL STRUCTURE OF COTTON FIBRE.

Sir,

Permit me to bring under your notice certain particulars respecting the mechanical structure of cotton fibre, the results of an investigation in which I have for some time been engaged.

When a filament of cotton is examined under the microscope, it is seen to be twisted on its own axis somewhat like a corkscrew — differing in this respect from fibres of silk, wool, and flax, which evince no natural tendency to twist.

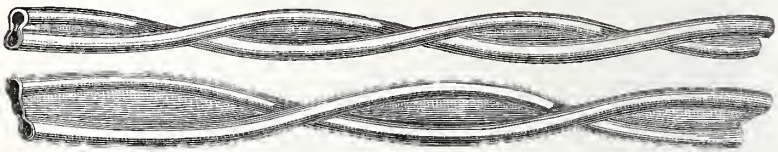
This peculiarity in the structure of cotton has been described by Mr. Thompson of Clitheroe, in a paper upon the Mummy Cloth of Egypt, which he read before the Royal Society, and by which he proved that that fabric was linen and not cotton, as had been previously supposed.

Mr. Thompson was indebted to the careful microscopic observations of Mr. Bauer for a clear indication of the distinctive peculiarities in the structure of cotton and linen fibres. He discovered filaments of cotton to be invariably *flattened* cylinders more or less *twisted;* whilst those of linen retained their cylindric form and were without twist.

These facts were demonstrated by a careful drawing, showing filaments of cotton and flax magnified four hundred times, which

was engraved in illustration of Mr. Thompson's paper.[1] About the same time, at the request of Mr. Pettigrew of London, Dr. Ure examined mummy cloth under the microscope with a similar result. He does not, indeed, so strongly insist on the natural twist of the fibre, but he distinctly alludes to its "spiral structure,"[2] and still more distinctly exhibits that peculiarity in all the woodcuts of magnified cotton fibres, figured in his *Philosophy of Manufactures*.[3]

The example here introduced is copied from a portion of the engraving of Bauer's drawing already referred to. It exhibits parts of two fibres of ripe cotton, each one-hundredth of an inch in length, magnified four hundred times.



The twist in cotton fibre has also been referred to by Dr. Royle in his "Culture and Commerce of Cotton in India," where an admirable example is figured of Sea Island cotton from a microscopic drawing prepared by Mr. Cornelius Varley for Mr. Thompson.

My own investigations, so far as I have been able to carry them, entirely coincide with the facts here recorded; but it may be satisfactory to say that an ordinary microscope, such as may be purchased for a few shillings, in the hands of an inexperienced observer exhibits the spiral structure of cotton fibres as shown by the woodcut on the margin.

As, however, the unaided eye fails to detect the slightest twist-

[1] This paper and engraving may be conveniently referred to in the Appendix to Baines's *History of the Cotton Manufactures*, where both have been republished.

[2] *Philosophy of Manufactures*, second edition, p. 101.

[3] *Ibid*, pp. 86, 87, 89.

ing even under the most favourable circumstances, it is not improbable that this peculiar corkscrew mechanism of the fibres of cotton has been observed by, and is known to, comparatively few of those parties most interested in its use, which may account for the fact that the natural twist has never been considered (so far as I can learn) with reference to its possible effect on any of the processes of the cotton manufacture.

On the authority of Mr. Bauer we learn that "the twists or turns in a fibre of cotton are from 300 to 800 in an inch."[1] My own observations upon different varieties of cotton lead me to believe the average number of twists to be very much less; and in this I am supported by the opinion of G. Lawson Esq., Demonstrator of Botany and Vegetable Histology to the Edinburgh University, who has recently examined specimens under the microscope at my request. Mr. Lawson reports that "the number of complete turns is in some cases equal to 200 in an inch, but more usually they are much fewer."

Mr. Bauer, who appears to have had favourable specimens for examination, states that fibres of cotton taken from unripe and unopened pods are always *untwisted cylinders*, and this form they retain ever after; but the fibres taken from ripe and open pods are *flattened and twisted*, and "in that respect they undergo no change through the operations of spinning, weaving, bleaching, printing and dying, nor in all the subsequent domestic operations of washing, &c., till the stuff is worn to rags; and then even the violent process of reducing those rags to pulp for the purpose of making paper, effects no change in the structure of these fibres." "With Ploessl's microscope," he adds, "I can ascertain whether cotton rags have been mixed with linen in any manufacured paper whatever."

From the authorities I have quoted, it may, I apprehend, be assumed that spiral twisting is a condition inherent in the fibres of ripe cotton, but which does not appertain to those which have been gathered unripe.

[1] Baines's *History of the Cotton Manufacture*, p. 537.

It would be interesting, and probably useful, to ascertain the exact time at which the flattening and twisting of the fibre occurs; most probably it accompanies and is caused by the desiccation of the fluid contained in the hollow cylinders of cotton upon exposure to the rays of the sun after the expansion of the protecting leaves. This can only be learned by a careful observation of the growing plant; but there is good evidence that the fibres, before and up to the time when the pod opens, are cylinders without any twist.

I suggest that yarn might be spun from cotton gathered when protected by the covering pod and before exposure to the direct action of the sun's rays, materially differing in many respects from that which is manufactured from the usual (so called) ripe cotton. It is very probable that so obvious an experiment may have been already tried and proved to be unsuccessful; as, however, I have never heard of it, I venture to suggest it, though it is merely incidental to the main purpose of this communication.

Whatever means nature may employ to produce the flattened and twisted arrangement of cotton fibre in the opened pod, it may be fairly assumed that the cause acts uniformly, and is followed by a uniform result. If the twist follows the course of the sun — a supposition powerfully supported by analogy of the known effect of its agency upon many other plants — then, the twist in all fibres in the same pod must be in one and the same direction; so also will be the case with each pod of the same plant, each plant of the field, each field of the district, and with each district of the hemisphere.

I have anxiously endeavoured to verify this hypothesis by careful observation of such specimens of cotton, in a proper state for the purpose, as I have been able to procure. These, I regret to say, have been exceedingly scanty, a fact which induces me to trouble you with this communication, as I have myself no opportunity of carrying out the enquiry or of obtaining the necessary samples; so that I can only hope to show you such facts as may induce you to take some interest in the subject, and also to

assist by procuring, through your correspondents in cotton growing countries, samples of cotton in the pod before and after its expansion, from various latitudes in both hemispheres.

Such observations as I have been able to make lead me to believe that the twist in cotton fibre follows the course of the sun. It is true that in almost every seed with its attached cotton I have yet examined, some of the fibres — more or less — appear to be twisted, *in a portion of their length*, differently from the greater adjacent mass; but this I apprehend to be the result of accident, as a very slight thrust disarranges the delicate filaments, and such is inevitable in the packing process as now conducted.

I am, however, by no means desirous that you should trust to my opinion in this matter, as I readily confess myself to be comparatively unpractised in the use of the microscope. I have therefore sought the assistance of the gentleman already mentioned, whose experience and skill in this department of science make his opinion of especial value. The following letter, though not to be considered conclusive, corroborates my own previous observations and shows the importance of further investigation upon proper specimens: —

University, Edinburgh, 8th July, 1857.

Dear Sir,

I have made an examination by the microscope of the specimen of Sea Island cotton sent by you, with reference to the point mentioned in your letter, viz., the direction of the spiral of the fibres, and I beg to report as follows:

The fibres are for the most part twisted from left to right (that is, in the direction of the sun's course); a few of the fibres, or at least portions of them, are twisted in the contrary direction (right to left, or against the sun's course); and portions of the fibre occur in which there is scarcely any twist at all, being in the form of a crumpled ribbon.

It may here be stated that the development of the cotton fibre has not been traced by any previous observer (so far as I can

learn), with the special view either of ascertaining the prevailing direction of the twist, or of investigating the conditions by which it is regulated. It is therefore impossible, from the examination of a single specimen of mature cotton, to predicate what may occur in other kinds of cotton, or even to say with certainty that the prevailing direction of twist in that specimen will also be found in other samples of Sea Island cotton, although I think such is extremely likely to be the case. The specimen of Sea Island cotton now submitted is certainly more *strongly* twisted than samples of Indian cotton which I examined some time ago.

In the event of your desiring a further prosecution of the subject, please bear in mind that unripe and unopened cotton pods are most instructive in such an investigation.

I am, dear Sir,
Yours faithfully,
G. LAWSON, F.R.P.G.,
Demonstrator of Botany and Vegetable
Histology to the Edinb. University,
Sec. Bot. Soc.

To Mr. Gilbert J. French,
Bolton, Lancashire.

I have examined numerous varieties of cotton wool, and find a great disparity in the number of twists in a given length of fibre when seen under the microscope. Unfortunately, I have no precise knowledge of the circumstances and locality of the growth of the specimens, and therefore dare not offer any opinion as to the probable cause of the greater or less twist. It would require a long continued series of careful observations by skilful microscopists, to arrive at any safe conclusion on this point. If I am at all correct in the deductions which I venture to draw from the facts already ascertained, and to which I shall now call your attention, you will agree with me that such an investigation is very highly important to the future interests of the cotton trade.

Cotton is (I believe) invariably spun into yarn without reference to the original and natural parallelism of its fibres. First the

saw gin in detaching the filaments from the seeds, and afterwards the scutching and blowing machine in its attempt to cleanse and separate the closely packed masses of fibre, entirely destroy the order in which these fibres had been previously arranged by nature. This produces two results, both of them detrimental to the succeeding processes of manufacture. I will mention the less important first.

Cotton fibre, whether examined under the microscope or in the flakes sometimes met with in bales with the natural arrangement undisturbed, is found to possess a pearly lustre, which in the finer kinds becomes almost iridescent. This quality appertains also to flax, and in a higher degree to silk, but is not observed in cotton thread or woven fabrics, except when imparted to them by factitious appliances — a practice so common as sufficiently to prove that the retention of the natural lustre is an object of importance.

This lustre is probably dependant upon the atomic arrangement of the cotton fibre. If these minute particles occupy uniform positions from the base to the point of the filament, each separate fibre and any aggregation of fibres arranged in natural parallelism receive and reflect the light that falls upon them — hence the lustre; but if this arrangement be reversed by placing the parallel fibres in somewhat equal numbers from point and from base, there can be no lustre, as the light is diffused from numberless reversed points instead of being reflected from a smooth surface composed of an aggregate of atoms uniformly arranged.

To make this more evident, let me refer to a similar effect produced by the same means upon another material. *Spun* silk is a technical name for threads prepared from waste silk and such cocoons as from accident or malformation cannot be reeled for use in the usual manner. These are treated much in the same way as cotton. The natural parallelism of the fibres is broken up by machinery, and a new arrangement brought about by dint of carding and roving. The threads resulting from this process resemble cotton much more than silk, and have lost in a great measure the brilliant lustre for which that material is principally valued.

Forty years ago linen thread and linen cloth possessed a lustre which is rarely met with in the manufactured flax of the present day. When spun by hand, the natural parallelism of the fibres was retained; but the practice in modern mills is, I am informed, to cut each long lock of flax into four lengths, which, after being heckled, are presented to the spinning machinery without regard to the natural direction of the fibres. Hence, as in the case of cotton and of spun silk, the reflecting surface of the material is broken up, and there is consequently a loss of the desired lustre, though the quality and strength of the thread may in all probability be improved. Arguing from the analogous effects upon silk and flax, I venture to hazard the inference, that a permanent lustre might be given to threads and fabrics of cotton by retaining the parallel position of the fibres which nature has established in the seed pod.

Assuming the hypothesis, that the twists in filaments of cotton are in one direction, to be correct, I suggest that, by continuing this arrangement throughout the process of spinning, the result promises a thread of greater tenuity, with more strength and smoothness, than can be produced by the present practice, which twists one moiety of the fibres composing a thread in the direction of the natural torsion and the other in the reverse direction.

I have shown that the spiral convolutions in ripe fibres of cotton *are permanent*. No process of manufacture, or of washing and wearing, succeeds in destroying or even modifying this peculiarity, and, as a necessary consequence, each distorted fibre exerts an unceasing effort to resume its natural position: hence the innumerable *ends* which perpetually show themselves on the most carefully manufactured cotton threads and fabrics. Human ingenuity may be said to have almost exhausted itself in the marvellous contrivances which have been applied to the removal or mitigation of this evil. The daring expedients of passing delicate threads and muslins over bars of red-hot metal, or through curtains of flame, are equalled by the contrivances of the bleacher in smoothing, polishing and fastening to the surface of the cloth

each rebellious point. These expedients serve, however, but for the time, since the friction of wearing and washing, and even changes of temperature alone, induce action in the elastic fibres thus unnaturally convoluted. They persist in an endeavour to escape from their constrained position, and are assisted by every strain upon the thread, as may be seen by the fresh points which at such times perpetually start from its surface.

If in spinning cotton the system of parallelism which nature has given to the filaments can be retained throughout the after processes, and the suggestive hint which she offers by that system to form the artificial twist in accordance with the natural torsion of the fibre, were acted upon, yarn would be produced with some amount of elasticity, on which a strain would have the effect of bringing all the component fibres into closer contact, their ends, whether point or base, all clinging inwards to the centre of the thread. The most perfect possible yarn (if I may be permitted to suggest its production as possible) would be that in which the number of artificial twists in a given length coincide with the natural twists in the fibres from which it is made.

It would be altogether premature to descant on the advantages which the cotton trade would derive from the use of yarn such as I have described. To you and to all practical spinners and manufacturers these will at once suggest themselves; and though you may perceive objections and impediments to its production which I have not noticed, yet your practice and experience may make you aware of means to overcome or elude these impediments, and also of numerous promising advantages which have not occurred to me. At all events, I trust I have shown such a case as may prove a sufficient excuse for intruding the subject on your notice.

At the present time, when the cry is not for *better* but for *more* cotton, it is probable that my suggestions may not be entertained, though I believe that even now they are worthy the serious consideration of fine spinners. But at some future period of depression in the cotton trade, when active competition stimulates improvement, I presume to predict that the views I have endea-

voured briefly to explain will be acted upon; and cotton, which is now held to be the humblest of all the fibres used for clothing humanity, may be elevated to a higher and more useful position—rivalling flax, and even silk, in the beauty of its lustre, delicacy, strength, and durability, as it now surpasses them in the universality of its utility.

There is one objection to the successful execution of the plan I have proposed, so obvious that it must instantly suggest itself to every mind. I allude to the evident difficulty of procuring cotton retaining its natural parallelism. Clearly the saw gin abroad and the scutching machine at home destroy this in the most effectual manner, and cotton, to be used as I propose, must not come within their injurious grasp.

The primitive modes of separating the seed from the fibres have been discontinued only because they could not keep pace with the increased speed of other machinery, and have given place to the American saw gin, which has nothing to recommend it but the facility of its operation and the large amount of bad work which it executes in a short time. I admit that in the present state of the trade the extensive use of the saw gin cannot be dispensed with, though its effect on the fibres is most injurious even when they are spun by the present process. The delicate and elaborate operations of carding are mainly intended to remedy the injury inflicted by the saw gin by forcibly dragging into parallel juxtaposition those fibres which it had previously disrupted. But I shall endeavour to show that by the ancient modes of operating upon the cotton pods, it may be effectually freed from the seed and the natural parallelism retained in its integrity.

The primitive method of separating the fibre from the seed, as practised by Indian females, was this. Conveniently seated, with a smooth slab placed on the ground before her, the woman arranges on it a quantity of cotton, freed by hand from the pod but retaining the attached seeds; over this she presses a roller by the action of her feet. The masses of fibre pass under the roller and fall over the edge of the slab next her person; but as the seeds

cannot pass beneath the roller, it tears them from the fibres and they fall over the edge of the slab at its opposite end. Now, to manage this operation in the quickest and most effectual way, it is evident that the bunches of fibre must be placed on the slab with their points next to, and their seeds farthest from, the roller; for if placed in a contrary position both seeds and cotton would be pushed together over the farther extremity of the slab. It follows, therefore, that the original position of the fibres with reference to each other need not be materially changed by this operation.[1]

The roller gin or churka, as formerly used in India, afforded the same or a still better result. The cotton was passed between fluted rollers of teak wood, placed so close together as to prevent the entrance of the seeds which were necessarily left behind. For the effectual working of this machine,[2] the cotton must have been presented to its action points first, and consequently it would pass from between the rollers undisturbed as to the parallel position of the fibres. If this cotton could be received from between the rollers in continuous flakes by any of the numerous ingenious methods common in British cotton mills (assuming it to be tolerably clean), it would be in a state ready for carding, possessing all the advantages of undisturbed parallelism of which I have endeavoured to show the importance.

It is possible — perhaps not improbable — that the delicate "webs of woven air," so fine as to be impalpable to the touch, and woven from threads "scarce discernible," for which Eastern India was so famous in former days, may have been made from picked samples of cotton, freed from seeds in the manner described above, carefully manipulated and spun in the undisturbed integrity of its natural arrangement. It is scarcely possible to imagine that such fairy-like fabrics could be produced from the dislocated fibres which the British spinner is compelled to use.

Sea Island cotton, a beautiful and expensive variety used by

[1] In Dr. J. Forbes Royle's *Culture and Commerce of Cotton in India*, p. 541, there is a figure of an Indian female using the foot roller.

[2] Engraved in Baines's *History of the Cotton Manufacture in Great Britain*, p. 66.

spinners of the finest yarns, is freed from its seeds by a gin, similar in principle to the East Indian churka; but its operation is aided by the action of a vibrating iron comb, which, together with the after treatment of tossing the fibres about in a wheel where they are exposed to a current of air, completely destroys their natural parallelism, though it avoids the damaging effect peculiar to the saw gin, — a machine which, by doubling many of the fibres caught in its teeth, and dragging them through apertures too narrow to admit the passage of the seeds, causes the ends of the doubled filaments to be brought in contact with each other; their convolutions then become entangled, and they remain permanently doubled up as comparatively valueless *waste* cotton.

It cannot be doubted that if the importance of preserving the natural position of the filaments was ascertained and acknowledged, effectual means would soon be taken to import cotton in a state fit for being spun in the manner I have proposed.

Let it be remarked that it is for certain purposes only, such as warps of all kinds, sewing thread, lace, shirting, &c. &c., that the proposed change would be at all useful. For the great bulk of the manufacture it would be unsuitable, and altogether objectionable for the wefts of such fabrics as have a raised or carded surface; but a richer and fuller pile might be imparted to these, by the use of weft spun in a contrary direction, that is, in opposition to, instead of in accordance with, the natural torsion of the fibre. The effect of this would be to double the number of ends subject to the raising action of the card.

I beg you to consider this communication as *suggestive* only. It claims to *prove* nothing. But the suggestions are such as, I hope, deserve attention, and this I respectfully solicit. I shall be glad if you can in any way subject my propositions to the test of actual experiment.

It is important that extended microscopic observations upon carefully selected samples of cotton in the pod, should establish or confute the assumption of uniform direction in the natural torsion of the fibre; and as the specimens required for this purpose can be

more easily obtained soon after this season of the year than at any other, I have somewhat hurriedly prepared this communication, copies of which I purpose to address to a few gentlemen occupying a prominent position in the cotton manufacture or trade; and also to such members of the Society of Arts as may visit Manchester during the ensuing week.

I have the honor to be,

SIR,

Your very obedient Servant,

GILBERT J. FRENCH.

Bolton, 1st August, 1857.

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